TUC RAIL
BELGIAN RAIL ENGINEERING

CALIFORNIA HIGH-SPEED TRAIN PROJECT

Operations and Maintenance
Peer Review

16/11/2010

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1. INTRODUCTION

Within the framework of the cooperation agreement between CAHSRA and the Belgian government signed on July 7th 2010, TUC RAIL was requested to represent the Belgian assignment to provide CAHSRA with technical assistance.

With great interest TUC RAIL experts have received and examined the California High Speed Train Project's 'Operations and Maintenance Preliminary Plan'.

As an international expert in high-speed rail systems, TUC RAIL is delighted about CAHSRA's intentions and is confident that such transport system will be of great success along the west coast in the US.

We are amazed about the profound work already done to compose the Operations and Maintenance Preliminary Plan, which demonstrates the weight and importance given to this initiative and the drive/determination to carry out the project.

As the aim of the present peer review was to look for major conceptual errors, and not to rewrite nor elaborate the documents in detail, TUC RAIL has examined the feasibility of the objectives set forth, based on its international expertise and knowledge. Besides these, also a few opportunities were pointed out.

In Chapters 2 and 3 TUC RAIL gives comment on the documents received, with referral to the pages concerned. Comments, reflections and suggestions are summarized in Chapter 4.

We hope that CAHSRA will find our comments valuable, giving additional – yet (at this stage) basic – insights.

2. DETAILED REVIEW OF INTRODUCTORY MATERIAL

2.1 Introduction

Page 1: "That means steel-wheel-on-steel-rail technology", " …on exclusive (dedicated) track" and "Extensive portions of the system will lie within, or adjacent to, existing rail or highway right-of- way"

It has to be noted that the alignment principles of a high speed railway differ from the alignment of a motorway. It seems obvious that typical radiuses cannot be maintained near the highway.

Design parameters are also related to the track type:

- ballasted track (for instance often implemented in France, UK, Spain, Belgium, Italy, Korea), or
- slab track (technology regularly implemented in Japan, Germany, the Netherlands, Taiwan)

For instance, gradients and maximal cant are more stringent on ballasted track.

Page 1 : "The route will be constructed at grade, in an open trench, in a tunnel, …"

Double bore tunnels (twin tube, single track) should be considered instead of single bore tunnels. In general, this concept is considered to be safer, due to the reduced probability of collision of trains and due to the better evacuation and rescue conditions. Additionally, twin-tube systems allow safer maintenance operation. Of course double bore tunnels are more expensive to build and operational costs are higher too. Especially in high-speed rail tunnels, attention is required in the field of aerodynamics (for instance: air pressure comfort, micro-pressure waves ("sonic boom"), etc…), climate, equipment and tunnel ventilation.

Pre-tunnels with calibrated holes can reduce negative effects; this principle has been implemented on the tunnel of Perthus between Spain and France. Calibration of these holes, based on the profile of a typical 'Thalys' train, was done by TUC RAIL in collaboration with the Von Karman Institute in Belgium.

Another important issue is the train speed in tunnels; till now we have no confirmation of the maximum train speed that can be allowed in tunnels; for the high speed project between France (Perpignan) and Spain (Figueras), coming into service at the end of 2010, the speed in the tunnel has to be minimum 300 km/h. The real speed will be fixed after separate tests with each type of high speed train.

The European Technical Specifications of Interoperability (TSI) for Rolling Stock ask for over pressed coaches for the new trains. These new technology can lead to higher tolerated speeds in tunnels.

Attention has to be paid for the operational safety rules in tunnels. Some countries don't tolerate more than one train in a tunnel. This means that the tunnel can affect the time schedule and the foreseen headway of five minutes.

Page 6: Full build Network – 2035

The stretch south of Los Angeles is the most dense section of the network, presenting 12 high-speed trains per hour in each direction, equivalent to an average headway of 5 minutes. Although this number of trains is still lower than the theoretical maximum capacity according to the UIC norm, we have to bear in mind that this norm supposes that the operator accepts that possible delay during peak hour service will be absorbed during off-peak. If punctuality has to be considered as a priority, then we deem that the number of trains has to be reduced, or that supplementary tracks have to be provided.

Another remark concerns the mixing of different train types stopping at different stations. Since the average speed of these trains will be different due to the time needed for stopping in the intermediate stations, this will negatively affect the capacity of the considered line section. Moreover, the dwell times in the intermediate stations are often subject to delays due to passenger movements, which will also influence the punctuality of the direct trains if the headway has been scheduled too tight.

2.2 Network Overview

No specific comment.

2.3 Service Plans

Page 7 : "twelve high-speed trains per hour in each direction during the morning and afternoon peak hours – equivalent to an average headway of five minutes."

The planned headway of five minutes depends on different design factors, such as the signaling system, the track alignment, the presence of tunnels, etc. Based on our experience, obtaining a headway of five minutes in high-speed rail systems is extremely difficult.

Page 10 : "The proposed mix of services offers regular clock face patterns, with each service type leaving at the same time each hour, with relatively limited exceptions"

We are not quite sure what is meant by "with relatively limited exceptions", but it gives us the opportunity to introduce the notion of the day time possessions for certain control operations.

The UIC document IF-7/96 "Maintenance of high speed lines", edited in April 1996[1] describes in Chapter 7, point 7.2-Possessions intended for monitoring" :

"These possessions are intended for making the detailed inspections of installations situated in the danger area and their characteristics should be as follows:

- *Daytime possessions on seven days out of seven, if necessary*
- *Duration: a minimum of 45 minutes*
- *Normal regular traffic stoppage*
- *Possession can be introduced at any point of the running track or at turn outs.*

The monitoring referred in Chapter 8 must, in certain cases, be carried out in daylight. In particular :

- *Daylight is necessary for the examination and evaluation of surface defects on the rail and its running surface.*
- *The inspection of switches and crossings requires daylights to permit the examination of damage to essential components such as cracks.*

…".

Daytime and daylight possession is still introduced – for safety reasons – in the service plan in certain countries (France, South Korea, Belgium); other countries (Germany, the Netherlands) don't follow this advise.

In the mean time the technology of monitoring switches and crossings has taken a quick development. RAMS analysis can help to decide on the necessity of daylight possessions.

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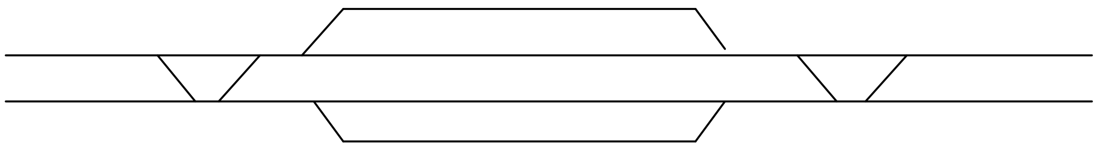
[1] a new edition of the UIC document "Maintenance of high speed lines" will be presented at the 7th World Congress of High Speed Rail, 7 – 9 December in Beijing. The work group on this matter was lead by a Belgian expert (retired director of TUC RAIL).

2.4 Passenger Stations Operations

Page 15 : "Figure 7 – Intermediate station – Typical Configuration"

We propose to add before and after the sidings a double link between the main tracks; this is useful for maintenance operations and in case of traffic disturbance due to technical incidents.



Page 16 : "Figure 9 – Terminal station Track cross sections"

We propose to add next to the outside walls (small) service platforms. They can be helpful for intervention on lighting, the overhead contact lines, cleaning the building, small interventions on the rolling stock, etc…

2.5 Rolling Stock Storage and Maintenance

Page 21 : "Fleet Requirements"

A total of 107 train sets are estimated for the full build Service plan. A train set can be either a 200 meter set or a 400 meter set.

We remark that:

- no double deck trains have been taken into consideration in order to offer a higher passenger capacity. Double deck high-speed trains (TGV Duplex) are commonly used in France; they offer about 35% more capacity for a same train set length and since the US clearance is larger than the European clearance, no major concessions should be made on passenger comfort.
- all the train sets are identical. Although managing an homogeneous park of rolling stock is very attractive (spare parts, training, spare ratio of trains, …), it should be examined if a homogeneous park has really the lowest Life Cycle Cost. A mixed park with train set types optimized for each type of service (express, limited-stop service and all-stop service) could possibly provide better economical results. Anyway, a maximum of standardization should be aimed for each type of train set.

Four types of Rolling stock are not mentioned:

- infrastructure maintenance machines (see below)
- a measurement train : dynamic control at high speed of the different functions of the Infrastructure subsystem (Doctor Yellow in Japan, IRIS in France, Archimedes in Italy). Tests are ongoing (Spain and Belgium) to incorporate the most important measurements (vertical and lateral acceleration of bogies and car floor) into a regular train set.

- "Pilot" or "Sweep trains": these trains run at reduced speed after major interruption of commercial traffic for checking the track stability after carrying out maintenance operations in track, for confirmation that the line is free from obstacles, for confirmation of absence of undetected defects and for confirmation of the behavior of the overhead contact lines and the signaling system. The maximum speed of these runs is 170 km/h; normally diesel locomotives are used for these runs. If not available the first regular train can do the job (running with a certain delay). In Belgium, Taiwan and in France these sweep runs are mandatory; in Germany they are done occasionally.
- Diesel locomotives and wrecking cranes in case of incidents and accidents.

2.6 Maintenance of Way

Page 25 : "Maintenance of Way Facility Locations and Configuration"

A track distance of 75 miles in each direction for Maintenance facilities is in our opinion really a maximum distance. For interventions at the end of the section with equipment traveling at 60 mph you need at least 2 times 1½ hour travel time. Some equipment (e.g. a train with ballast hoppers) doesn't even reach this maximum speed and hence needs more travel time whilst working time is reduced.

Below some figures (average coverage) on HS-networks:

- Belgium: between 45 and 64 miles
- Italy: between 19 and 34 miles
- France: 43 miles on LGV Méditerranée, 48 miles on Paris-Lyon
- Spain: between 93 and 112 miles
- Taiwan: 43 miles

We remark that the link between each MOWF site and the HST System should not be realized with a standard turnout, but with a turnout with movable frog, since no gap should be present in the high-speed tracks.

2.7 Train Dispatching and Control

No specific comment.

2.8 Manpower Estimates

Page 27 : "Required Manpower Staffing – Maintenance of Way and Infrastructure"

It is very difficult in this stage to give comments on the required Manpower staffing.

For information we can give some data of a recent benchmark.

<table>
<tr><th>Number of staff per single track km</th><th>Spain</th><th>Italy</th><th>Belgium</th><th>Taiwan</th></tr>
<tr><td>Track</td><td rowspan="2">0.072</td><td rowspan="2">0.08 – 0.14</td><td rowspan="2">0.10– 0.12</td><td></td></tr>
<tr><td>Civil work</td><td>0.26</td></tr>
<tr><td>Energy and OCS</td><td>0.33</td><td>0.09 – 0.12</td><td>0.063 -0.07</td><td>0.339</td></tr>
<tr><td>Signaling</td><td rowspan="2">0.046</td><td rowspan="2">0.095 – 0.11</td><td rowspan="2">0.055</td><td>0.243</td></tr>
<tr><td>Communication</td><td>0.171</td></tr>
<tr><td>Others</td><td></td><td></td><td>0.04</td><td></td></tr>
</table>

The manpower for MOW differs from country to country but can also, in the same country, differ from line to line. Many decision factors have to be taken into account : lay out of the line, presence of tunnels, UIC class of the line, allowed working windows, distance between maintenance bases, outsourced work, contractual availability of the line, reliability of the subsystems, etc.

2.9 Project Status

Page 31 : "Scope of Analyses : 7. Factors affecting infrastructure maintenance"

A 5 hour overnight "window" is within the average duration all over the world. If necessary the "window" of the second track (not planned to operate on it) can be reduced at 4 hours.

Below some figures of working "windows" on HS-network:

- Belgium: over day 40 minutes to 1 hour; overnight 6 hours on one track, 4 hours on both tracks
- France (Paris-Brussels): over day 1 hour; overnight about 5 hours on one track and 4 hours on both tracks
- Spain: no window over day; 4 hours overnight on both tracks
- Taiwan: 4.5 hours overnight on both tracks

2.10 Operational Assumptions

Point 1 : dedicated tracks

The more the high-speed network is independent from the domestic network, the more the service will be reliable and less influenced by external factors.

Point 2 : train set capacity

By using double deck train sets, capacity can be increased by 35% (see above).

Points 3 and 4: clock face patterns

This approach is not only customer friendly, but also creates easy operational conditions. Attention has to be paid that timetables should take into account the worst cases, i.e. during peak hours.

Point 5 : priority

The priority between different train types should be fixed by the Infrastructure Provider.

Point 6 : grade separated crossings

This is absolutely necessary, not only for safety reasons, but also in order not to reduce line capacity.

Point 7 : service plans

Service plans are prepared for a busy weekday, in order to be prepared for the worst case.

Point 8 : equipment cycles

As explained in article 3.3 of this peer review report, immobilization time in terminal stations can be reduced by using train sets with seats in both directions.

Point 9 : daily equipment utilization

Combining multiple services allows indeed in certain cases to reduce dwell time in terminal stations. Anyway, an optimum between minimum dwell times and sufficient buffer time for absorbing possible traffic disturbance has to be defined.

2.11 Questions and Issues

Point 7 : Overall viability of shared operations

It is very common in Europe that HS trains operate on domestic lines, since high-speed lines are linked with the conventional network and don't form a separate network. The reason can be:

- giving access to existing stations (e.g. Brussels, Paris, Rotterdam, Liège, …)
- extending the HST – service on (upgraded) lines on the conventional network (link between the Belgian border and Köln, link between Lyon and the Swiss network, etc.).

In that case train sets have to be equipped for traveling on these links (overhead catenary system, signaling system). The speed has to be adapted to the lay out of the infrastructure.

The opposite situation – domestic trains running on high-speed lines – also exists; e.g.:

- on the Belgian HS-speed line between Louvain and Liège Thalys trains are running at 300 km/h, ICE 3 trains at 270 km/h and IC trains at 200 km/h; between Antwerp and Amsterdam Thalys trains are running at 300 km/h whilst Fyra trains will run at 250 km/h;

- on the line Perpignan-Figueras between France and Spain HS trains will run at 350 km/h and freight trains at 100 km/h.

If domestic trains have to operate on HS-networks, some problems have to be solved:

- the clearance has to be adapted for both systems;
- the dynamic effects between a HS-train crossing a commuter train have to be checked [2] (the 4.7 meter distance between the Express Track Centers (figure 8) should be enough in our opinion);
- the track lay out has to be adapted; the radius of the curves has to take into account the speed of the fastest train;
- the cant in the curves has to be defined taking into account two factors:
    - the comfort of the passengers in the coaches of the high speed train;
    - the wear of the lowest rail.

  Generally the cant will be lowered.
- the design of the platforms has to be done in detail based on the fact that the rolling stock for the commuter passenger trains is normative while this rolling stock exists. If common solution can be found on the side of the rolling stock the civil infrastructure has to be adapted to both types of trains. Possibilities are :
    - dedicated platforms for each type of train (not an economical solution)
    - dedicate the outside platforms (see our remark on figure 9 on page 16) to commuter trains
    - devise the length of some platforms into a platform for simple unit TGV trains (220 - 240 m) and a half of the length to commuter trains (maximum length of the commuter train + 25 meter).
    - more sophisticated technical solutions (adaptable parts of platforms)?
- the commuter trains have to be equipped with the on-board signaling adapted to the high speed line.

Passenger trains hauled by diesel locomotives should only give specific problems in long tunnels and in underground stations. Specific studies have to be made for extraction and ventilation.

Point 9 : Late- night passenger trains versus maintenance of way activities

Two remarks have yet been formulated:

- the possibility to have a gain of 1 hour on one of both tracks (4 hours without traffic instead of 5 hours)
- the possibility to use the sweep train for commercial purposes (reduced price?)

Point 12 : dwell times

Intermediate station dwell times of 1.25 to 1.50 minutes are unrealistic, taking into account the time needed for opening the doors, passengers unloading and loading passengers, closing the doors and final checking before leaving. Especially passenger movements are unpredictable and can seriously disturb the time schedules.

Finally, passengers are more sensible for possible delays than for the absolute journey time; hence we recommend to provide enough dwell time in the intermediate stations.

[2] studies have even been done for the crossing of HS-trains with freight trains

Point 27 : Infrastructure Maintenance Plan and Asset Management System

As already mentioned in footnote 1, UIC intends to present a new Report concerning Maintenance of High-Speed Lines on its World Congress in December 2010. Since its previous Report IF-7/96 “Maintenance of High Speed Lines” has become somewhat obsolete due to fundamental changes in the railway environment, such as liberalization and privatization, new techniques and new contract types, the UIC Plenary Committee decided in 2008 to start up a new Workgroup ”Maintenance of high-speed lines” taking into account:

- the experiences gathered the last decades,
- the most recently technologies on infrastructure,
- the other subsystems with their latest technological evolution,
- the interfaces between operators (rolling stock) and infrastructure managers (maintenance),
- the extended experiences and specificities in other countries out of Europe (Japan, Korea, Taiwan).

Specific RAMS (Reliability, Availability, Maintainability and Safety) and LCC (Life Cycle Cost) studies should be performed during the design of infrastructure and railway equipment, in order to optimize maintenance.

3. DETAILED REVIEW OF TECHNICAL MEMORANDUM

3.1 Phase 1 Service Plan TM 4.2

We refer to the remarks above, which generally concern the following items:

- Average headway of 5 minutes is too short in our opinion
- Dwell times in intermediate stations are too short
- Use of double deck rolling stock offers more capacity (up to 35%) and counters capacity problems, which already occurs from 2030 on, according to Figures 1 to 4.

3.2 High-Speed Train Service Plan – Full Build Network

Same remarks as in 3.1.

3.3 Terminal and Heavy Maintenance Facility Guidelines

Page 9 and 10 : Tables 3.1.2 and 3.1.3

The information concerning the TGV North is not complete: in Brussels there is an additional workshop for the maintenance of trains running on the TGV North (Paris-Brussels-Köln-Amsterdam-London).

This workshop has the facilities for Maintenance Level II, for storage and indoor and outdoor inspection.

Page 18 : Cleaning

The time needed for turning the seats so that passenger scan seat toward the running direction seems not been taken into account in the Critical Path Activities chart on Figure 10 of the “Introductory Material”; if this option is confirmed, additional time and staff have to be provided.

European rolling stock provides seats in both directions and with different combinations (1 seat, 2 seats, 2+2 seats) hence offering accommodation for single passengers and for groups. Hence, we deem that this option is not relevant.

3.4 Summary Description of Requirements and Guidelines for: Heavy Maintenance Facility (HMF), Terminal Lay-up/Storage and Maintenance Facilities & Right-of-Way Maintenance Facilities

Page 2 : 4.0 Right of way maintenance

“The connection between the high speed track and the MOWF can be made with a “standard” turn out.” We understand a turnout with lower speed in the switching section, but still with movable frog.

Page 2 : Operations control center

The ideal concept is to centralize the different “operational” functions in one room to have direct visual contact; more precisely:

- the train operations control;
- the supervisor of the maintenance operations;
- the rolling stock distribution officer;
- the electric power distribution officer.

Centralization presents the advantage of direct communication in case of incidents or accidents.

An open question is the necessity of redundancy of the operations control center, as it is the case for example in Japan en foreseen on the International Section between Perpignan and Figueras (high speed line linking France and Spain).

4. CONCLUSIONS

The review of the Operations and Maintenance Preliminary Plan gave us the conviction that already profound work has been done, presenting many detailed analyses and proposals. This Plan also covered the most important fields concerned by the high-speed train project.

Our major remarks concern 2 subjects.

Firstly, we deem that the proposed service plan will be too sensitive for possible cumulative delays, due to several factors:

- the mix of train types with different stopping patterns and hence different average speeds;
- the average headway between 2 trains during peak hours on some stretches, which seems too short;
- the dwell time in the intermediate stations, which is unrealistic and should become larger.

Secondly, we are wondering that the use of double deck train sets has not been considered, since it could offer a solution to the saturation which is already foreseen from 2030 on.

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